Appl. No.: 10/039,290
Amdt. Dated: 12/07/2005
Off. Act. Dated: 09/08/2005

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (currently amended): An apparatus for providing non-contact thermal measurements at high spatial and thermal resolutions, comprising:

an illumination source;

means for generating [[a]] an electrical signal in response to registration of the magnitude of light received from said illumination source that is reflected from the surface of an object;

said means for generating a signal comprising an illumination detector;

means for subjecting said object to modulated thermal excitation; and

means for generating a bandwidth-limited AC-component of the signal from said illumination detector in response to changes in thermoreflectivity from a surface of said object arising while said object is subjected to said modulated thermal excitation.

2. (currently amended): An apparatus for providing non-contact thermal measurements at high spatial and thermal resolutions, comprising:

an illumination source;

an array of individual illumination detectors;

said illumination detectors configured to generate signals in response to registration of the magnitude of light received from said illumination source that is reflected from the surface of an object; [[and]]

a circuit for modulating the thermal excitation of said object at a known frequency; and

a signal processor;

said signal processor configured to filter one or more direct current components from said signal while said object is subjected to modulated thermal excitation to discern a ~~small~~ thermoreflectance signal associated with said known frequency, from noise.

3. (original): An apparatus as recited in claim 1, wherein said means for generating a signal in response to registration of the magnitude of light received from said illumination source that is reflected from the surface of an object comprises:

an array of individual illumination detectors.

4. (original): An apparatus as recited in claim 3, wherein:

said array of illumination detectors is adapted to generate information on the intensity of light received by each of said individual illumination detectors in the array.

5. (original): An apparatus as recited in claim 1 or 2, further comprising:

a display;

said display adapted for displaying a bandwidth-limited AC-component of the signal.

6. (currently amended): An apparatus as recited in claim 1 or 2, further comprising:

means for receiving a bandwidth-limited AC-component of the signal associated with a known frequency of said modulated thermal excitation and computing a thermal measurement based on a change in registered surface reflectance.

7. (original): An apparatus as recited in claim 6:

wherein said object has a known thermoreflectance constant; and

wherein said change in registered surface reflectance is in response to a change in the thermoreflectance coefficient of the surface material of said object resulting from a temperature change associated with said thermal excitation.

8. (original): An apparatus as recited in claim 1 or 2, further comprising:

means for generating a superresolution image from a combination of thermal images having a lower spatial resolution.

9. (original): An apparatus as recited in claim 8, wherein said means for generating a superresolution image comprises:

a computer; and

programming associated with said computer for,

receiving a plurality of thermal images having a first image resolution, and

combining said thermal images having said first resolution by interpolating pixel values into a thermal image having a higher second resolution.

10. (original): An apparatus as recited in claim 1 or 2, wherein said illumination source comprises a laser light source.

11. (original): An apparatus as recited in claim 10, wherein said laser light source operates at wavelength ranging from approximately 500 nm to approximately 800 nm.

12. (original): An apparatus as recited in claim 10, wherein said laser light source has a wavelength of approximately 655 nm.

13. (original): An apparatus as recited in claim 10, wherein said laser light source has an output power ranging from approximately 1 mW to approximately 100 mW.

14. (original): An apparatus as recited in claim 10, wherein said laser light source has an output power of approximately 5 mW.

15. (original): An apparatus as recited in claim 1 or 2, further comprising:

an x-y translation stage;

said translation stage configured to provide motion to said illumination source and said illumination detector in relation to the surface of said object;

wherein a thermal image may be constructed from data collected during scanning of the surface of said object.

16. (original): An apparatus as recited in claim 15:

wherein said x-y translation stage comprises a piezoelectric translation stage;

wherein said translation stage provides movement resolution that is approximately equal to or higher than the desired spatial resolution at which the object is being measured.

17. (original): An apparatus as recited in claim 1 or 2:

wherein said illumination source is configured to generate a beam spot size that approximates, or is less than, the desired spatial resolution of thermal measurement.

18. (original): An apparatus as recited in claim 17, further comprising:

an inverse-filter which is applied to remove image blurring caused by an excessively large illumination spot size.

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19. (original): An apparatus as recited in claim 1 or 2, wherein said illumination detector comprises a photodiode.

20. (original): An apparatus as recited in claim 2 or 3, wherein said array of illumination detectors comprises an array of photodetectors ranging in size from approximately 16 x 16 array to approximately 64 x 64.

21. (original): An apparatus as recited in claim 2 or 3, wherein said array of illumination detector comprises an array of photodetectors ranging in size from approximately 2 x 2 to approximately 256 x 256.

22. (original): An apparatus as recited in claim 1 or 2, wherein the frequency range of said modulated thermal excitation to which said object is subjected ranges from approximately 0.1 Hz to approximately 100 kHz.

23. (currently amended): An apparatus as recited in claim 1, wherein said means for generating a bandwidth-limited AC-component of the signal from said illumination detector while said object is subjected to modulated thermal excitation comprises:

a signal processor;

said signal processor configured to filter one or more direct current components from said signal to discern a ~~small~~ thermoreflectance signal from noise;

said filter adapted with a passband associated with said thermal excitation.

24. (original): An apparatus as recited in claim 2 or 23, wherein said signal processor is selected from the group of narrow band filters consisting essentially of a lock-in amplifier, differential boxcar averaging circuit, and FFT analyzer.

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25. (original): An apparatus as recited in claim 2 or 23, wherein said signal processor is configured to filter out components of the signal other than a single harmonic of the registered illumination level.

26. (currently amended): A method as recited in claim 25:

wherein said single harmonic that is at, or associated with, the frequency of thermal modulation to which said object is subjected.

27. (original): An apparatus as recited in claim 2 or 23, wherein said signal processor is configured to pass a band of frequencies that is less than approximately 10 Hz.

28. (original): An apparatus as recited in claim 2 or 23, wherein signal processor has a passband having a maximum width of approximately 1 Hz.

29. (original): An apparatus as recited in claim 2 or 23, wherein said signal processor is configured to pass a band of frequencies that is limited to approximately 0.1 Hz.

30. (original): An apparatus as recited in claim 1 or 2, further comprising:

an imaging device adapted to receive a portion of the reflected illumination for aligning position of the illumination source in relation to the object.

31. (original): An apparatus as recited in claim 30, further comprising:

a splitter configured to direct portions of said reflected illumination to said imaging device.

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Claims 32-39 (canceled)

40. (currently amended): A method for providing high resolution thermal imaging of an object being subjected to thermal modulation at a known frequency range, comprising:

illuminating an area on the surface of an object for which thermal information is desired;

detecting illumination reflected from said area; and

generating an AC-coupled bandwidth-limited signal in response to detected illumination associated with the known frequency of thermal modulation and thermoreflectivity changes of said object.

41. (original): A method as recited in claim 40:

wherein said AC-coupled signal has a bandwidth with a center at, or associated with, the frequency of modulation to which said object is subjected.

42. (original): A method as recited in claim 40, further comprising:

resolving the AC-coupled signal into an image.

43. (currently amended): A method for providing high resolution thermal imaging of an object being subjected to thermal modulation at a known frequency range, comprising:

illuminating an area on the surface of an object for which thermal information is desired;

detecting illumination reflected from said area in response to changes in thermoreflectance of the surface as subjected to thermal modulation;

generating an AC-coupled bandwidth-limited signal in response to detected illumination within the known frequency range; and

resolving the AC-coupled signal into an image.

44. (currently amended): A method as recited in claim 43:

wherein said AC-coupled signal has a bandwidth with a center at, or associated with, the frequency of thermal modulation to which said object is subjected.

Claims 45-48 (canceled)